CEMP-EA/ CEMP-ET Engineer Technical Letter 1110-3-455	Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000	ETL 1110-3-455 25 June 1993
	Engineering and Design HUMIDITY CONTROL FOR BARRACKS AND DORMITORIES IN HUMID AREAS	
	Distribution Restriction Statement Approved for public release; distribution is unlimited.	

CEMP-EA
CEMP-ET

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, D.C. 20314-1000

ETL 1110-3-455

Engineer Technical
Letter 1110-3-455

25 June 1993

Engineering and Design
HUMIDITY CONTROL FOR BARRACKS AND DORMITORIES IN HUMID AREAS

1. Purpose. This letter provides design guidance for controlling humidity in barracks and dormitories in humid areas.

2. Applicability. This letter applies to all HQUSACE major subordinate commands, districts, and field operating activities (FOA) having Army or Air Force military construction design responsibility.

3. Background. Mold and mildew flourish in the high humidity found in many buildings (especially barracks and dormitories) in hot humid climates. Interior humidity sources must be dealt with in any climate, but entry of exterior moisture in a hot humid climate may overpower the air conditioning in the summer. This persistent moisture will support mold and mildew growth which damages materials and affects the health of the building occupants.

4. Discussion. Remediation involves a combination of minimizing the entry of moisture through the building envelope while continually removing moisture from the interior with an effective HVAC system. Further details are provided in the enclosure.

5. Action to be Taken. Designs for new or refurbished barracks or dormitories in humid areas should incorporate modifications of HVAC and building envelopes as recommended in the enclosure.

6. Implementation. This letter will have routine application as defined in paragraph 6c, ER 1110-345-100.

FOR THE DIRECTOR OF MILITARY PROGRAMS:

Encl

RICHARD C. ARMSTRONG, P.E.
Chief, Engineering Division
Directorate of Military Programs

DESIGN CRITERIA FOR THE CONTROL OF MOLD AND MILDEW IN BARRACK/DORMITORY TYPE OCCUPANCIES IN HUMID AREAS

1. INTRODUCTION - Application of existing Army and Air Force criteria for barrack/dormitory type facilities in humid areas does not ensure space humidity levels necessary for personnel comfort or to prevent mold and mildew growth. High ambient moisture conditions reverse vapor flow through building components compared to the vapor flow in cooler climates. The vapor flow into the building increases the latent load on HVAC equipment. These unique conditions require innovative design solutions. Mold grows best between 62 percent and 93 percent relative humidity over a range of temperatures between 25 degrees C (77 degrees F) to 30 degrees C (86 degrees F). Comfort cooling inside design dry bulb temperature shall be 8.3 degrees C (15 degrees F) less than the 2-1/2 percent outside dry bulb weather condition, but will not exceed 25.6 degrees C (78 degrees F) dry bulb or be less than 23.9 degrees C (75 degrees F) dry bulb. The design inside relative humidity will be 50 percent. These criteria apply to new and renovation projects in humid areas. Humid areas are defined as having over 3000 hours of 19.4 degrees C (67 degrees F) or higher wet bulb temperature in combination with an outside design condition of 50 percent relative humidity or higher, or over 1500 hours of 22.8 degrees C (73 degrees F) or higher wet bulb temperature in combination with an outside design condition of 50 percent relative humidity or higher, based on 2.5 percent dry bulb and 5.0 percent wet bulb temperatures.

2. BUILDING ENVELOPE

a. General: Air infiltration and the permeability of construction materials allow steady intrusions of water vapor. Infiltration flow rates increase with wind pressures.

b. Building Leaks: Anything that stops the air flow will reduce infiltration of water vapor. Even with positive interior pressure, winds and convection currents introduce continuous flows of warm humid air through open seams, joints, and gaps around doors and windows. A small air leak can introduce more water vapor than large areas of permeable material. Openings must be sealed to minimize infiltration of humid air.

c. Vapor Retarders: Vapor retarders offer resistance to the diffusion of moisture across a plane, have a maximum permeability of 0.5 perms, and must be located to minimize condensation within the wall section. Normally, the vapor retarder in humid areas should be located outside of the wall insulation. The use of an

exterior vapor retarder does not eliminate the need for the escape of moisture from the interior portion of the wall. Water vapor will condense at the first cold surface, which may be inside the wall. Such water vapor should be vented into the air conditioned space, or be prevented from entering the building wall. An exterior vapor retarder resists the gross penetration of moisture from outside, but moisture will intrude from gaps in the retarder. The water vapor will collect inside the wall cavity and must subsequently be allowed to escape.

d. Requirements: The building envelope design shall:

(1) Place the least permeable material or vapor retarder on the outside of the building insulation, and place materials with greater permeability materials inside the building insulation. The permeance of exterior finish systems (EIFS) and similar systems must be investigated by the designer and applied to ensure that the least permeable material is placed on the outside of the building insulation.

(2) Provide interior surfaces of exterior walls that will allow water vapor within the wall to escape into the conditioned space. Vinyl wall coverings, multiple coats of oil based paint, and other vapor resistant materials will not be used as interior finishes of exterior walls. The permeance of less obvious vapor resistant interior finish systems, such as ceramic tile in grout with adhesive, must be investigated by the designer and applied to maintain an escape for moisture towards the conditioned space.

(3) For double wythe walls, place the vapor retarder on the outside of the inner wythe.

(4) Analyze the vapor flow through the building insulation systems, wall sections, and roof/ceiling sections. The variety of roof/ceiling systems available to the designer and the concepts associated with attic ventilation prevent definitive requirements from being established. However, roof, ceiling, and insulation systems should reflect the following principles:

(a) Place the vapor retarder outside the thermal envelope created by the insulation. In some cases, the roof membrane may serve as the vapor retarder.

(b) Ventilate spaces created outside the roof/ceiling vapor retarder.

(c) Prohibit outside air entry into spaces created inside the thermal envelope formed by the roof/ceiling insulation. Ventilation of such spaces, if required, must use air from the

conditioned space.

(5) Seal all openings around doors and windows, sills, jambs, and heads, pipe and other utility penetrations, seams in vapor retarders and air barriers, intersections of walls and roofs, etc. Weatherstripping should be used in the same manner as in colder climates.

(6) Ensure that moisture transfer from ventilated attics into the building is minimized the same as walls.

(7) Provide details to minimize thermal bridging, especially at door and window frames and intersections of walls or roofs.

(8) Provide sufficient floor to floor height, vertical distribution space, and mechanical equipment space to accommodate a ducted all air HVAC system.

3. MECHANICAL SYSTEMS

a. New Facilities: New facilities shall employ central station air handling units that supply conditioned air to variable air volume (VAV) terminal units with integral heating coils. Variable air volume terminal units shall be the air throttling type consisting of a pressure independent air valve which is modulated in response to space temperature. Fan-powered terminal units shall not be used. Fan-coil unit air conditioning equipment shall not be used.

b. Existing Facilities: Existing facilities to be rehabilitated shall incorporate variable air volume systems as described for New Facilities in item a. above.

c. General Requirements:

(1) Terminal Heating: Terminal heating shall be applied locally at the conditioned space. The terminal heating design shall utilize recovered heat in accordance with American Society of Heating, Refrigerating and Air-Conditioning Engineers Illuminating Engineering Society (ASHRAE/IES) Standard 90.1 for reheat and other simultaneous heating and cooling.

(2) Reheat: Air-conditioning systems applied in less humid geographic areas normally distribute cooling air between 12.8 and 15.5 degrees C (55 and 60 degrees F). In humid areas, lower cooling coil discharge air temperatures are necessary to provide for "drier" air delivery to the spaces and offset moisture gains through the building envelope. The lower cooling coil discharge temperatures associated with the "drier" air

increase the potential for overcooling the spaces at minimum air flow conditions to the spaces. A reheat coil, located just downstream of the central fan, may be desirable to maintain duct temperatures more in line with normal duct distribution temperatures, and will offset any increased potential for condensation and/or overcooling. The application of this reheat coil shall be in accordance with ASHRAE/IES Standard 90.1 for reheat and other simultaneous heating and cooling. Access sections shall be positioned between the fan and the reheat coil.

(3) Heat Recovery: All forms of heat recovery systems shall be considered for Army projects. Air Force projects shall use condenser heat recovery. Use of heat recovery for reducing the domestic hot water load will also be considered on all projects.

(4) Preheat: Some humid area applications may require tempering or preheating the minimum outside air to prevent freezing, and nuisance trips of the freeze protection devices. The designer shall determine the winter design mixed air temperature resulting from mixing the minimum outside air quantity at the lowest expected winter outside air temperature and the return air at its expected condition. If necessary, the central air handler shall be provided with a preheat only coil located in the minimum outside air duct to temper winter supply air for the VAV system. Preheat coil control shall be provided to maintain a constant preheat coil leaving air temperature.

(5) Heating: An appropriately sized heat source shall be provided to meet the heating requirements and to back up the sources of recovered heat.

(6) Control: Control strategies shall be as specified in U.S Army Technical Manual, TM 5-815-3, Heating, Ventilating and Air-Conditioning (HVAC) Control Systems and as indicated below. A control schematic is shown at Figure 1.

(a) Space heating for VAV systems shall use variable air terminal units with integral heating coils. Control shall be proportional type by the variable air terminal controller in response to a room temperature sensor. Heating coil control valve shall be modulated open only after the primary air supply to the space is at the minimum setting. Army projects shall further delay the opening of the heating coil control valve until the temperature in the space drops through a deadband of at least 2.7 degrees C (5 degrees F). Air Force projects shall not incorporate such a deadband.

(b) Cooling/dehumidification shall be accomplished by chilled water cooling coils in the air handling units. Control

shall be constant leaving air temperature. The leaving air set point for VAV cooling coils shall be determined from an engineering and psychrometric system analysis considering not only full design loading, but also, the part load performance as the space sensible load falls to zero. Chilled water temperatures must be set sufficiently and maintained consistently low to allow the cooling coil to achieve the desired leaving air dry bulb and dewpoint temperature.

(c) Economy cycles, dry bulb or enthalpy initiated, have limited value when applied to VAV systems, in humid areas, for barrack/dormitory facilities, and shall not be used.

(7) Ventilation Air: Minimum outside air quantities shall comply with ASHRAE Standard 62 or as required for building pressurization, whichever is larger.

(8) Building Pressurization: Positive static pressure shall be maintained to reduce infiltration. At all load conditions, supply air flow shall be at least 110% to 120% of exhaust air flow for all spaces with direct mechanical exhaust.

(9) Space Exhaust System: A central ducted exhaust system shall be used in lieu of individual exhaust fans for each space. The exhaust systems shall run continuously and shall be interlocked with the building supply air system. The exhaust duct for each space shall have a manual volume damper accessible from the space for proper balancing.

(10) Air Path: Return air shall be ducted. Closet and storage spaces shall have louvered doors and the return air shall be drawn through these spaces. In the event that there are no closets or storage spaces, the air shall be returned through the utility area between the living space and the bathroom. All air distribution paths shall comply with NFPA 101 and NFPA 90A.

(11) Equipment Selection:

(a) Cooling coil fin density shall be indicated in the equipment schedules at 315 fins/meter (8 fins/inch) maximum to ensure a cleanable coil, and competitive bidding. Face velocities shall not exceed 2.8 m/s (550 ft/mm) to preclude moisture carryover.

(b) The minimum number of cooling coil rows shall be specified in the equipment schedules. The number of rows shall be based on a comparison of data from at least three manufacturers and shall ensure that the latent cooling loads can be met or exceeded.

(c) Cooling coil entering and leaving air conditions shall be specified (wet and dry bulb temperatures) at the maximum airflow rate.

(d) In general, control of supply and return fans for VAV systems is complex. Return fans should be used only where required for proper air distribution.

(12) <u>System Layout</u>:

(a) To the maximum extent possible chilled water piping shall not be concealed in walls or ceilings of occupied spaces.

(b) Insulation on chilled water piping shall be cellular glass type with an external vapor barrier.

(c) Access panels, sufficiently sized, shall be located for maintenance of VAV boxes, dampers, controls, and associated components.

4. COMMISSIONING - Successful conditioning of barrack/dormitory occupancies in humid areas depends upon the proper interactions of both the building's envelope and the building's mechanical systems. HVAC systems will be commissioned to verify and document the actual performance of the HVAC systems and evaluate conformity with the design intent. Air Force ETL 90-10, Commissioning of Heating, Ventilating, and Air Conditioning (HVAC) Systems Guide Specification or Corps of Engineers Guide Specification, CEGS 15995, Commissioning of HVAC Systems will be used to develop contract requirements for commissioning.

5. REFERENCES

a. U.S Army Technical Manual, TM 5-815-3, Heating, Ventilating and Air-Conditioning (HVAC) Control Systems.

b. Corps of Engineers Guide Specification CEGS 15995, Commissioning of HVAC Systems.

c. Air Force ETL 90-10, Commissioning of Heating, Ventilating, and Air Conditioning (HVAC) Systems Guide Specification.

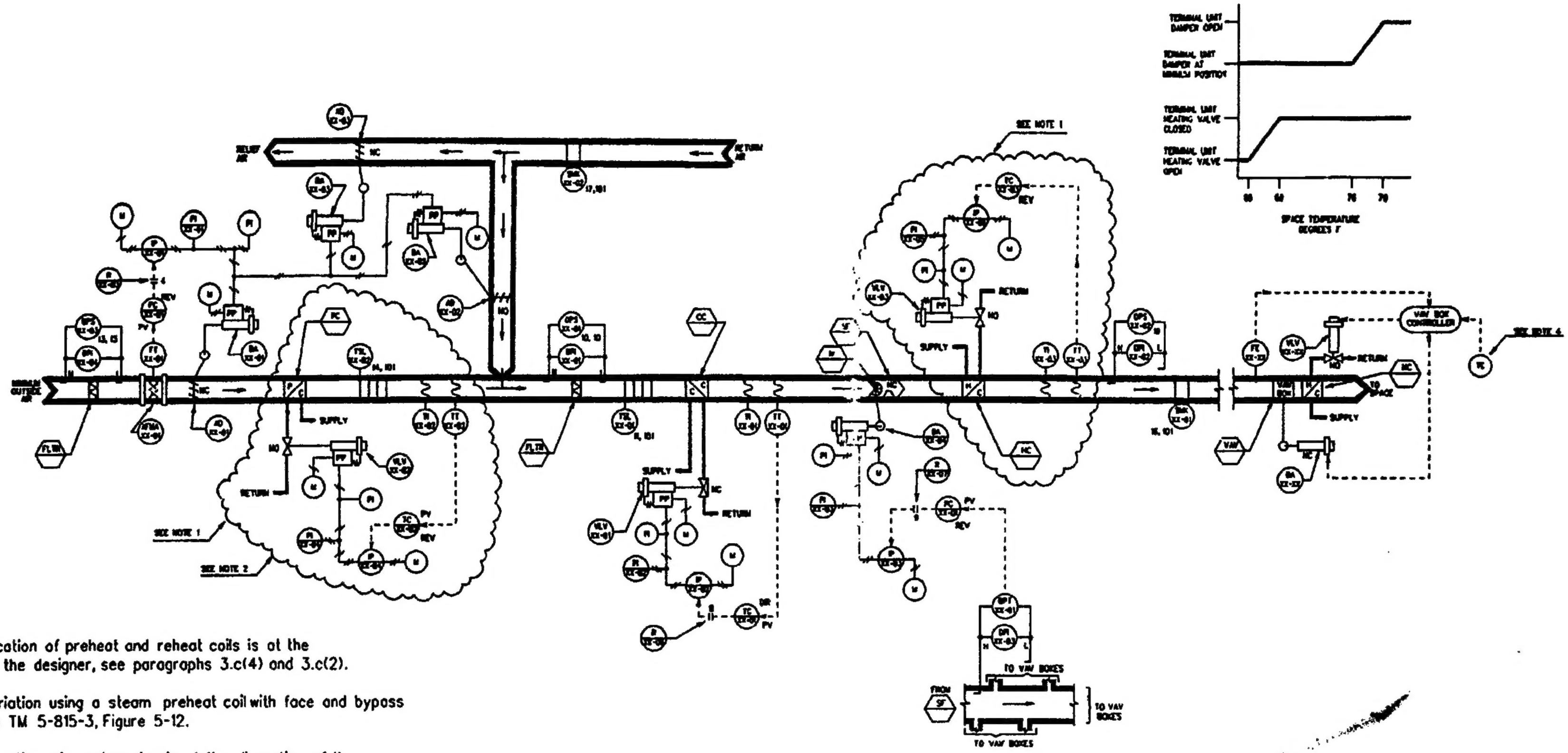
d. ASHRAE Standard 62 (Latest Edition), "Ventilation for Acceptable Indoor Air Quality," American Society of Heating, Refrigerating and Air Conditioning Engineers, 1791 Tullie Circle, NE, Atlanta, GA 30329.

e. ASHRAE/IES Standard 90.1 (Latest Edition), "Energy

Efficient Design of New Buildings Except Low-Rise Residential Buildings," American Society of Heating, Refrigerating and Air Conditioning Engineers, 1791 Tullie Circle, NE, Atlanta, GA 30329.

f. National Fire Protection Association (NFPA) Codes may be obtained from: National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

ENCL



NOTES

1. The application of preheat and reheat coils is at the discretion of the designer, see paragraphs 3.c(4) and 3.c(2).

2. For a variation using a steam preheat coil with face and bypass dampers, see TM 5-815-3, Figure 5-12.

3. The application of a return fan is at the discretion of the designer. If the use of a return fan is required, the designer shall add the return fan controlloop depicted in TM 5-815-3, Figures 4-18A through 4-18F.

4. For barrack applications, the following requirements should be added to the specification for zone terminal-unit controllers (CEGS 15950, para. 2.16.2):
   a) Occupant-accessible setpoint adjustment.
   b) Occupied/Unoccupied setpoints.
   c) Occupant-accessible Occupied/Unoccupied mode selection.

5. For barrack applications, provide a hand-switch in place of a timeclock for HVAC System Occupied/Unoccupied mode selection.

Figure 1 - Humid Area VAV Schematic